

NASA AMES RESEARCH CENTER

STEP High School Astrobiology Summer Camp

LIPIDS

Photo credit: Russell Virgilio

OUTLINE



1. What is Astrobiology?
 - a) how does Astrobiology relate to Lassen?
2. What are lipids?
3. Lipids in microbes
 - a) how can lipids help us to identify microbes in the environment?
 - b) examples from Yellowstone and Lassen
4. Lipids in old rocks
5. Search for evidence of microbial life on Mars using lipids
 - a) Mars Science Laboratory SAM instrument package



What is Astrobiology?



Astrobiology is the scientific study of the origin, evolution, distribution, and future of life on Earth and in the universe.

- How does life originate and evolve?
- Is there life beyond Earth and, if so, how can we detect it?
- What is the future of life on Earth and in the universe?

<http://astrobiology.nasa.gov>



- Astrobiology is a collaborative effort
 - microbiology, ecology, astronomy, geology, paleontology, and chemistry
- Researchers begin by studying life on Earth
- Earth is the only planet that we know has life!
- Microbes have inhabited Earth for 9/10ths of its history
- It's likely that microbes will be the type of life we will find elsewhere in the universe
- Where do we find microbial ecosystems today?
- We study analog systems

We hope to understand how life existed on early Earth and other planetary bodies

<http://astrobiology.nasa.gov>

ANALOG SYSTEMS



- Extreme environments on Earth
 - hot springs
 - deep sea hydrothermal vents
 - deep subsurface
 - polar regions
 - hypersaline ponds
 - arid environments
 - endolithic communities
 - high UV





Extremophiles

Thermophile = **heat-loving**

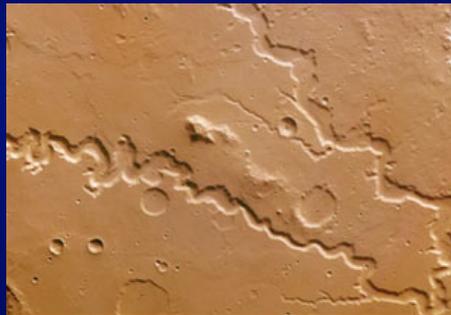
Acidophile = **acid-loving**



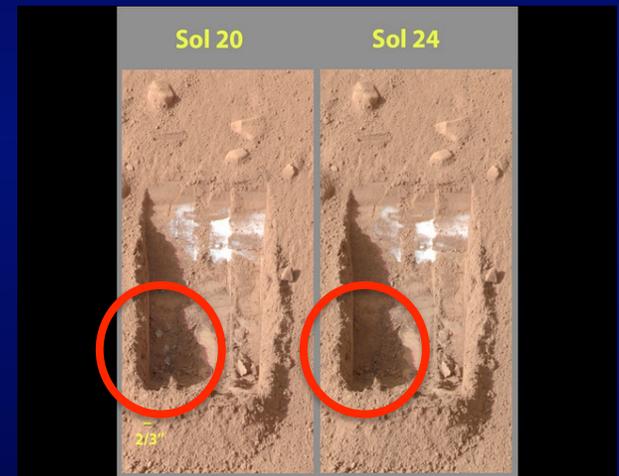
LIFE ELSEWHERE?



- Possible environments on other planetary bodies that could host microbial life
 - Follow the water!
 - Mars



Spirit, Opportunity



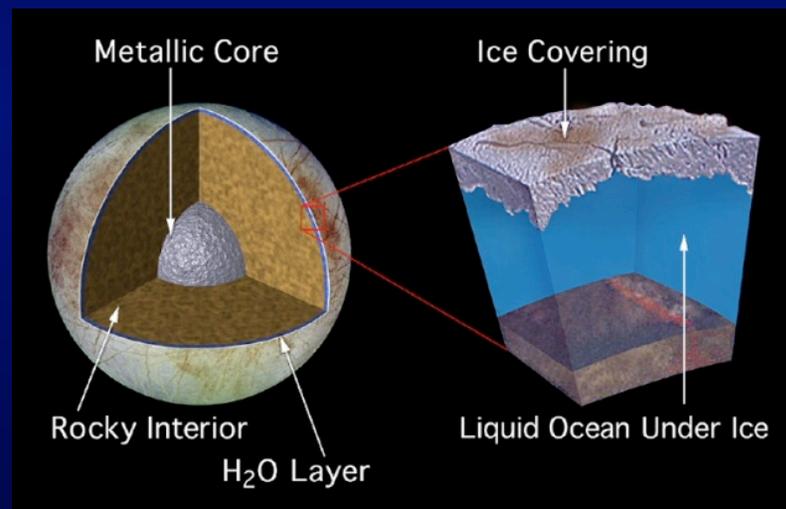
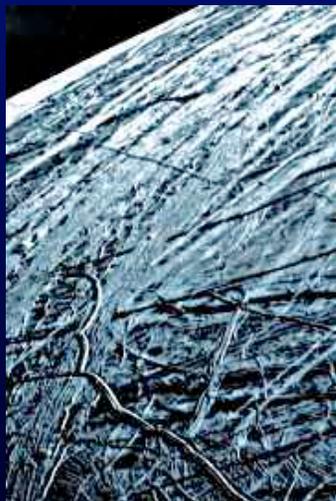
Phoenix

LIFE ELSEWHERE?

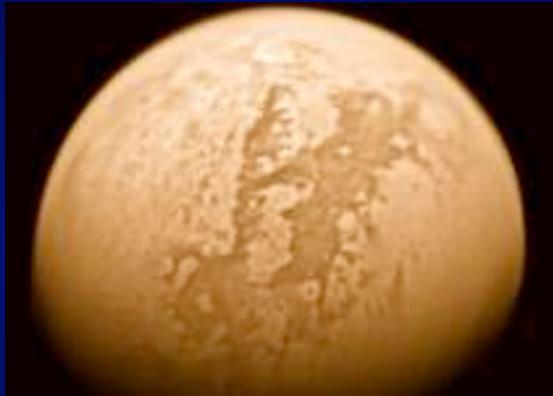


“ICY WORLDS”

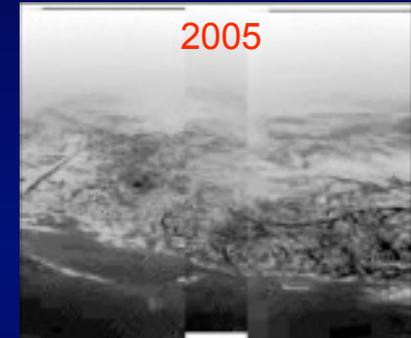
Jupiter’s moon Europa



LIFE ELSEWHERE?



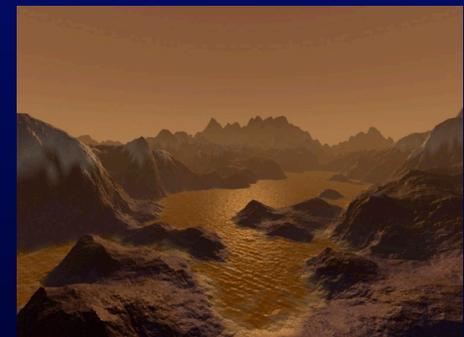
Saturn's moon Titan
-prebiotic chemistry



NASA Cassini mission
ESA Huygens probe



Ice volcanoes erupt liquid water

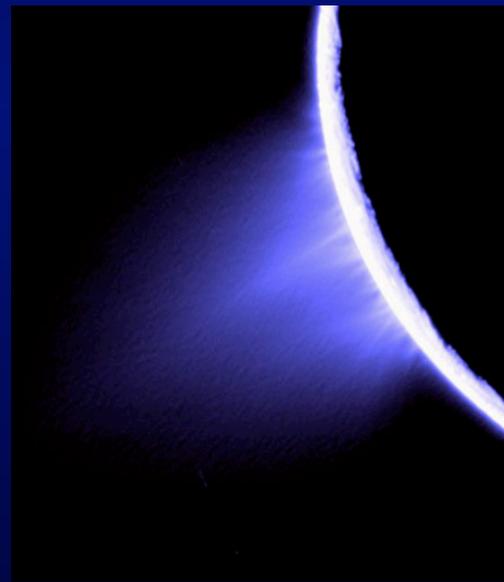
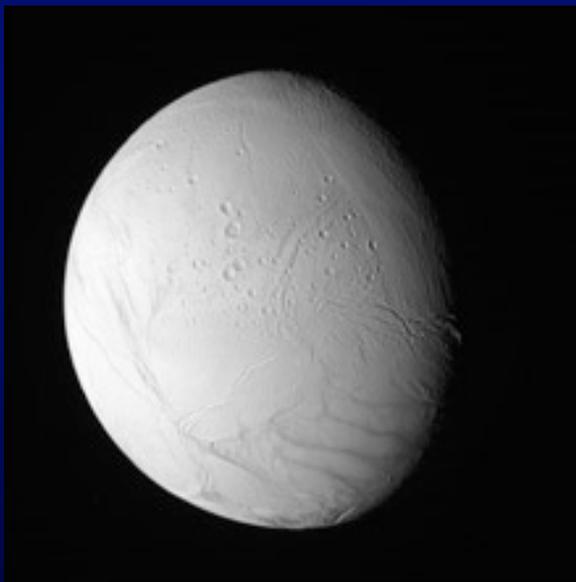


Ethane lakes

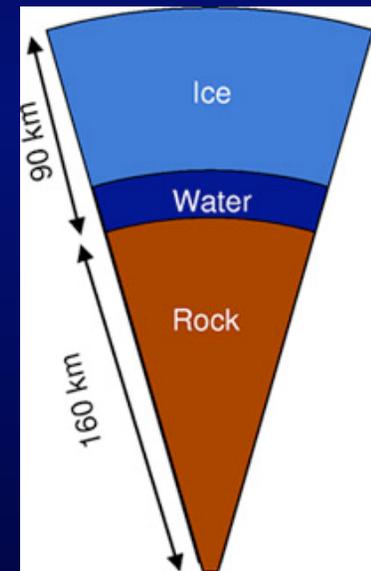
LIFE ELSEWHERE?



Saturn's moon Enceladus



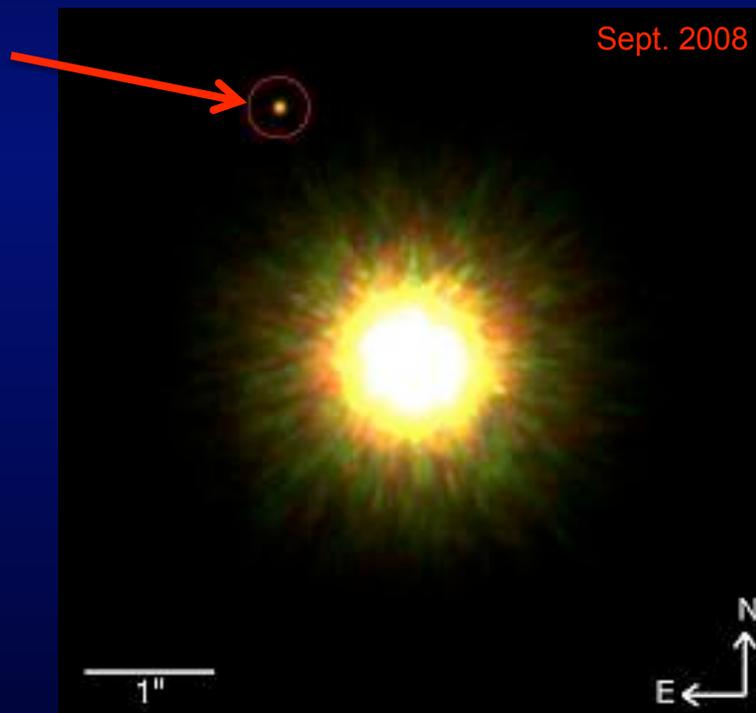
Plumes of H₂O vapor erupting



H₂O ocean?



Extrasolar planets



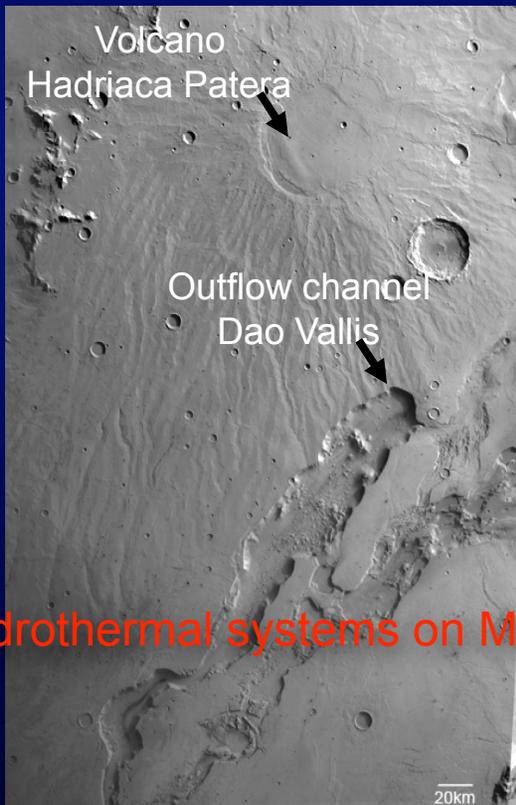
first picture taken of a likely planet orbiting a distant, sun-like star

Gemini telescope, Hawai'i

LASSEN



How does Astrobiology relate to Lassen?



Hydrothermal systems on Mars?



silica!

- Hot spring?
- *Fumarole*?

Was there a Lassen-type hydrothermal systems on Mars??

ASTROBIOLOGY
LIFE IN THE UNIVERSE

BIOSIGNATURES



How do we look for evidence of life on Mars?

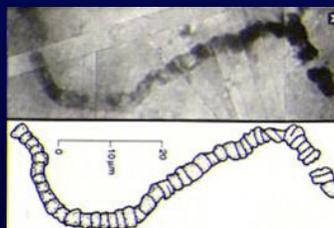
Biosignatures

BIOSIGNATURES

Microbially-influenced
sedimentary structures
e.g., stromatolites

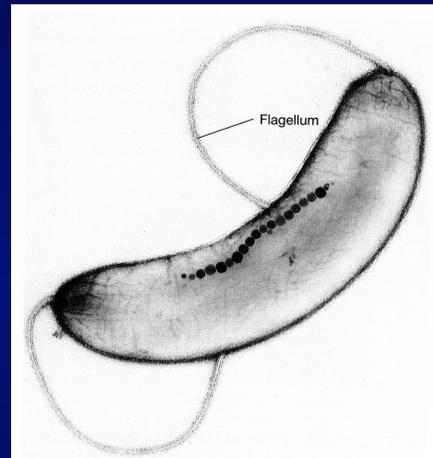


Microbial fossils



Chemofossils

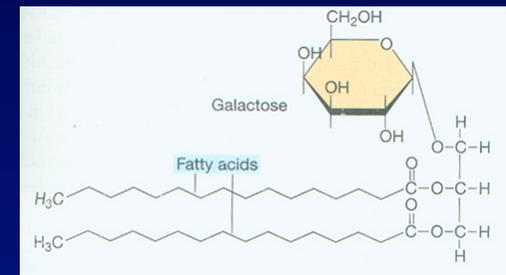
Biominerals
a) BCM



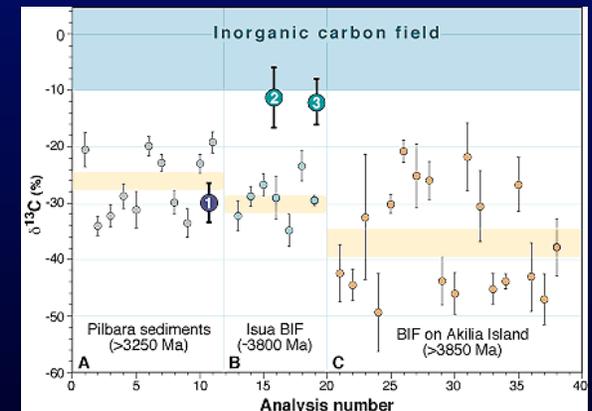
b) BIM



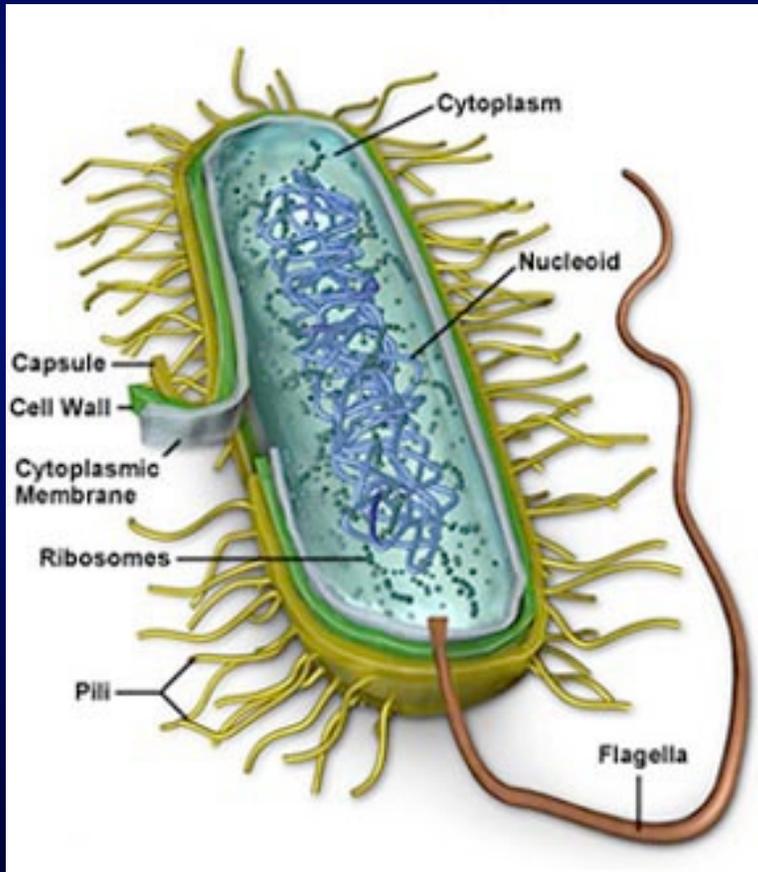
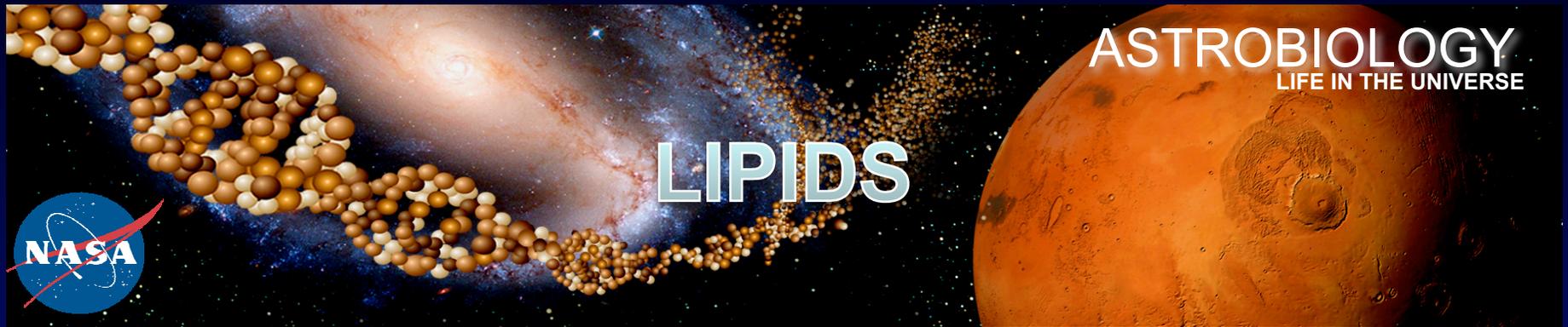
Lipid biomarkers



Stable isotopic fractionation



LIPIDS

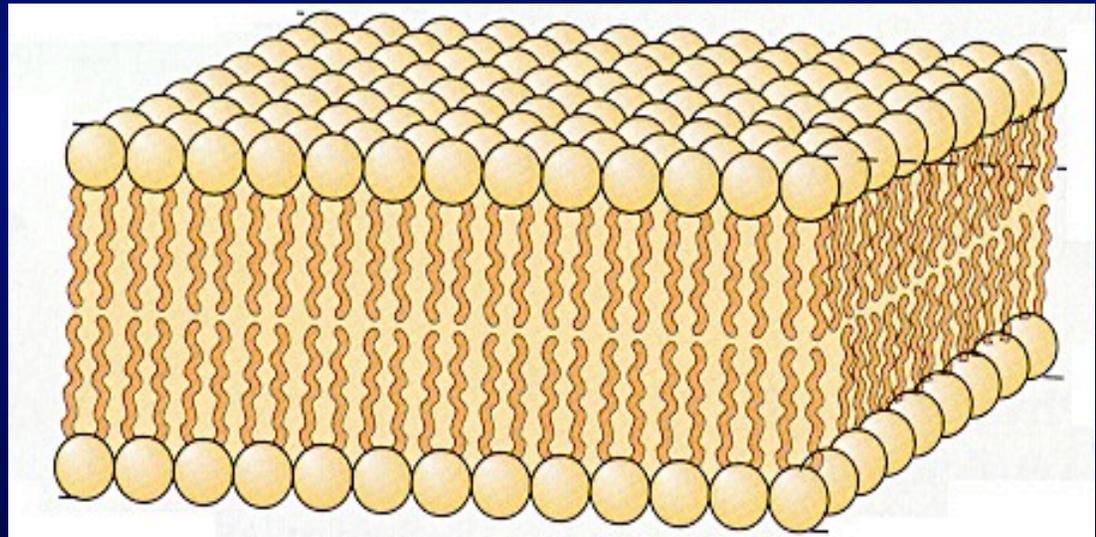
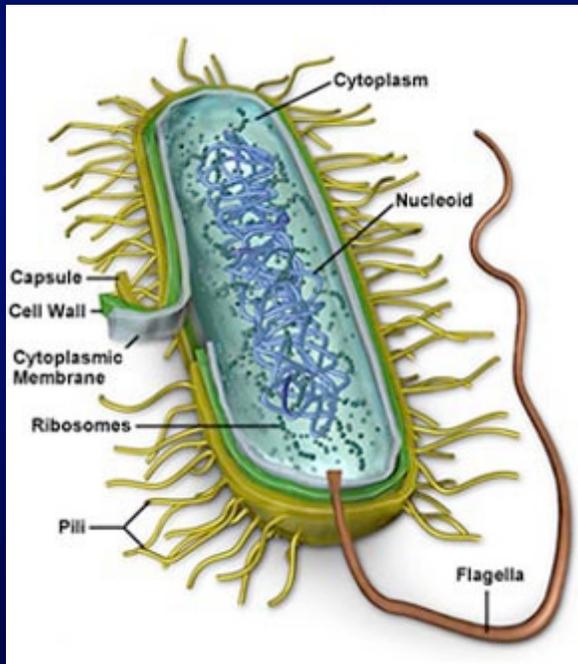
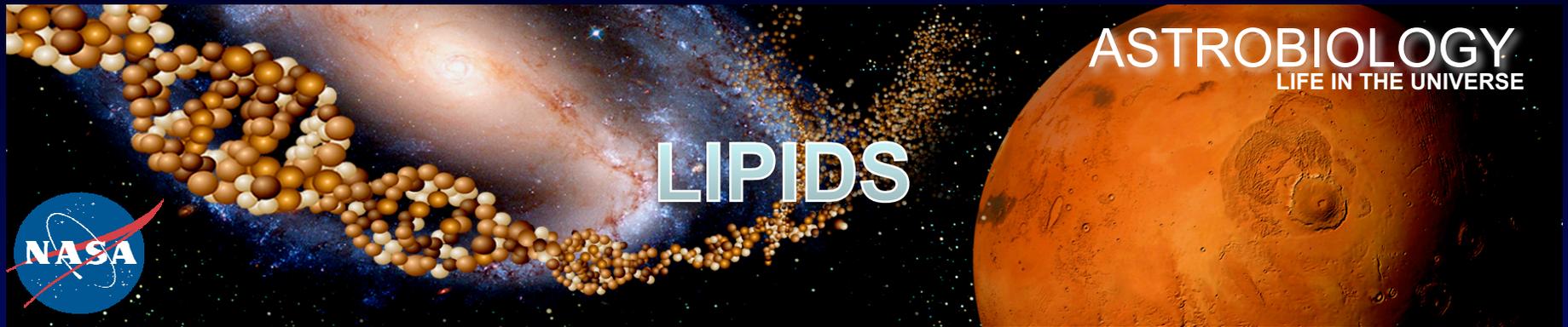


What are lipids?

Types:

1. Oils, fats
2. Waxes
3. Sterols

LIPIDS

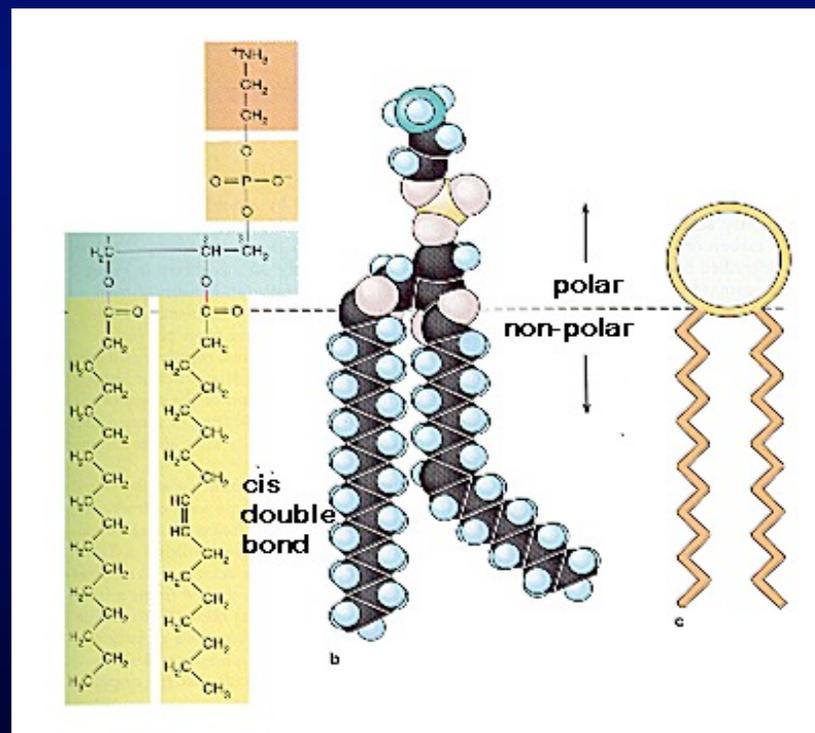


Lipid bilayer

LIPIDS



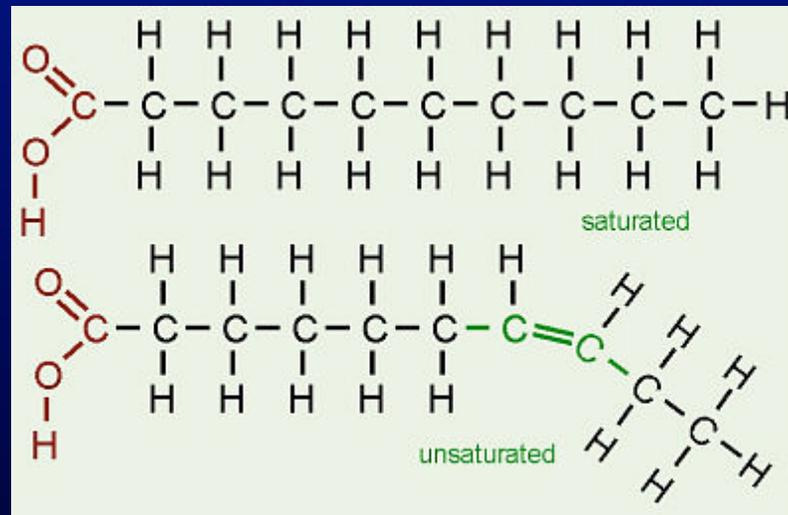
Mono-, Di-, and Tri-glycerides



LIPIDS



Saturated, mono-unsaturated, and poly-unsaturated

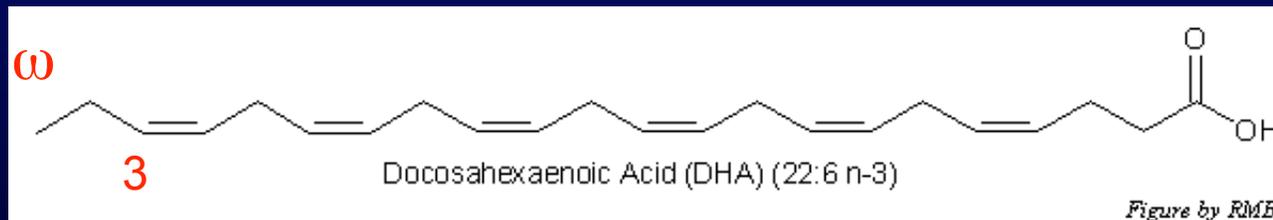
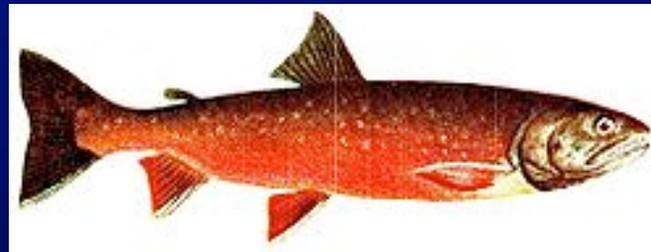


LIPIDS



Saturated, mono-unsaturated, and poly-unsaturated

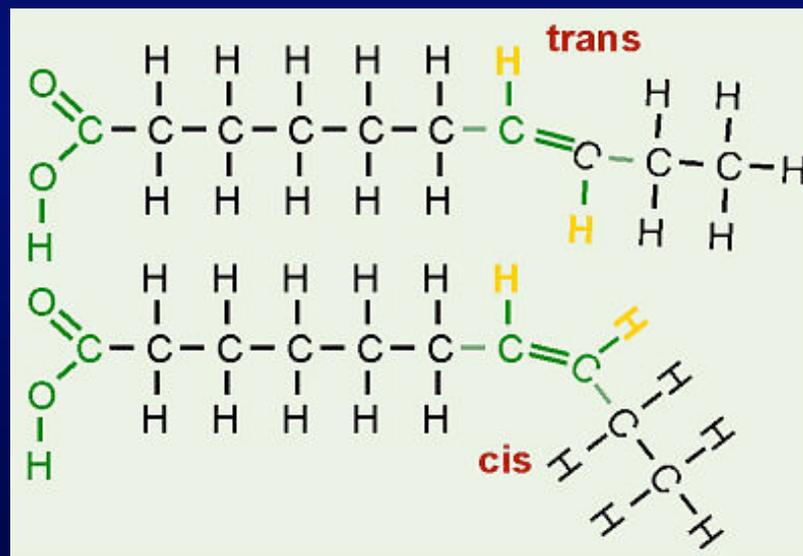
Fish oil: omega-3 fatty acids



LIPIDS

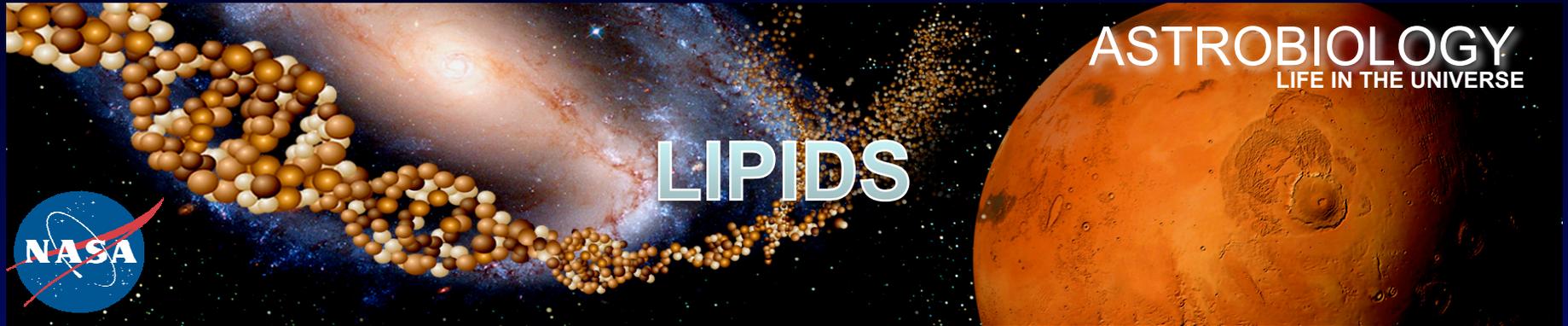


Trans fats

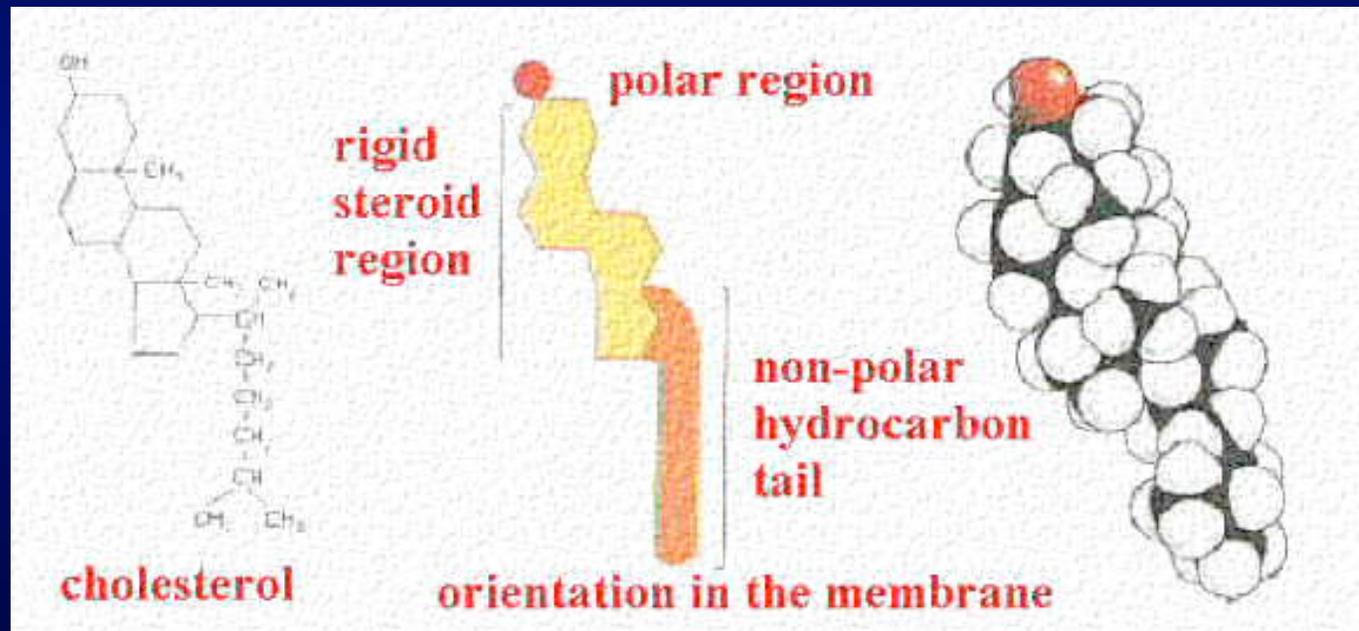


Cis bonds transform to trans upon heating
Trans fats = carcinogens!!

LIPIDS

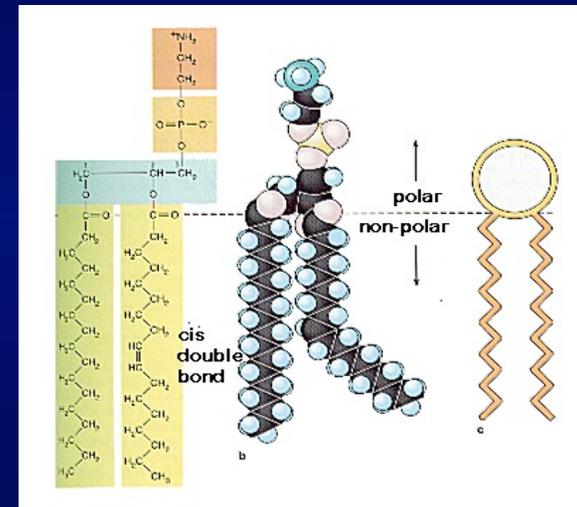
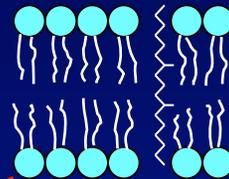
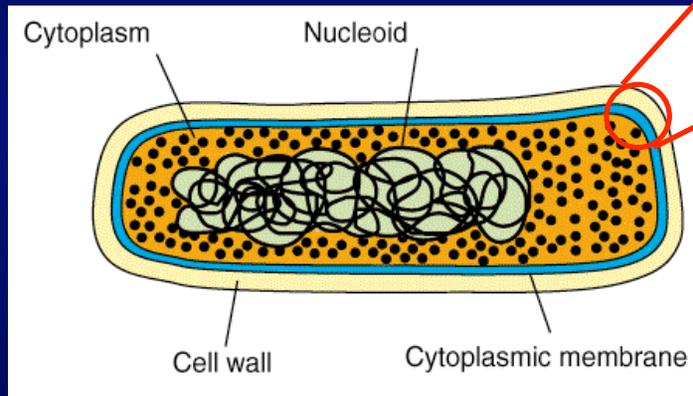


Cholesterol



Precursor to hormones (aka steroids!)
Vitamin D

LIPIDS IN MICROBES



Ester-linked membrane fatty acids

Who's there?

ASTROBIOLOGY
LIFE IN THE UNIVERSE

LIPIDS IN MICROBES

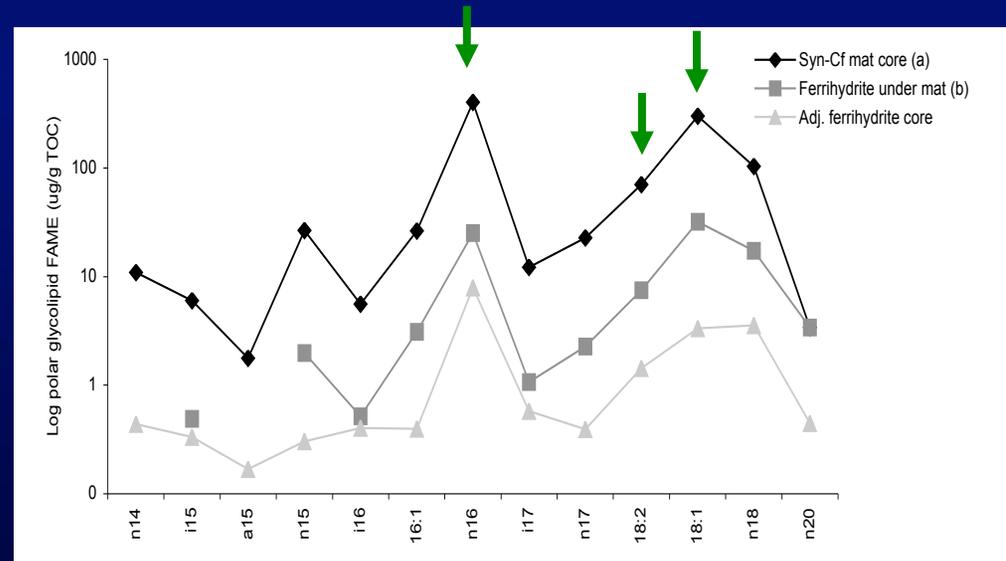
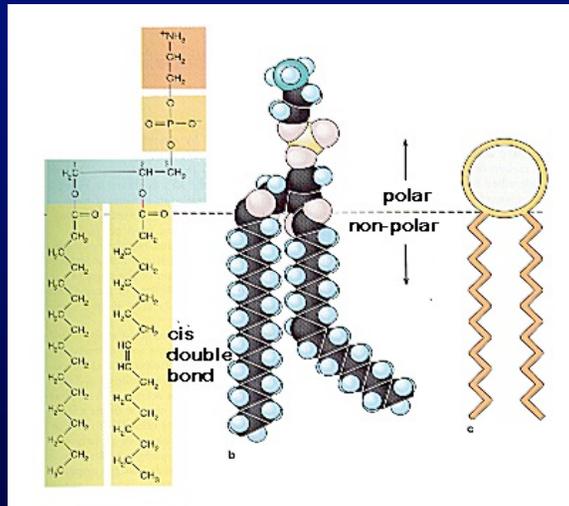


Grand Prismatic hot spring
Yellowstone

LIPIDS IN MICROBES



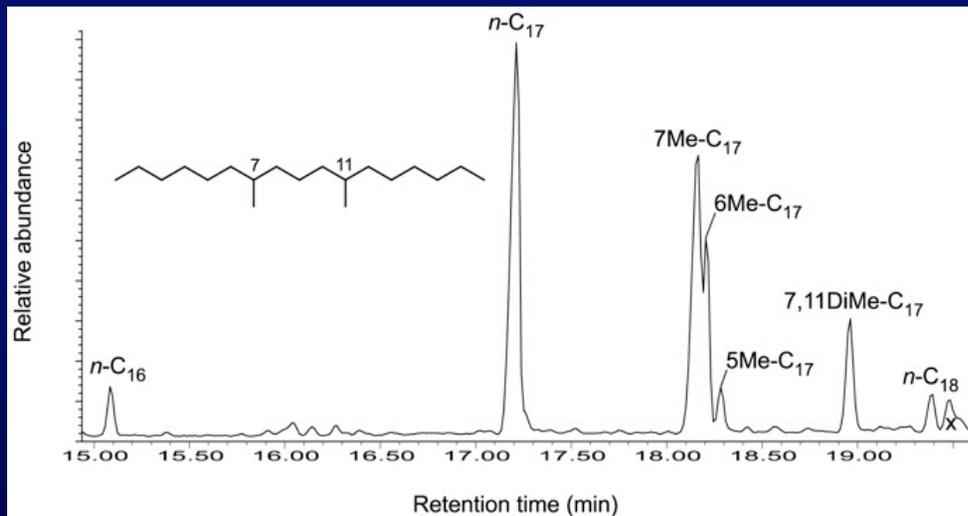
Who's there?



LIPIDS IN MICROBES



cyanobacteria



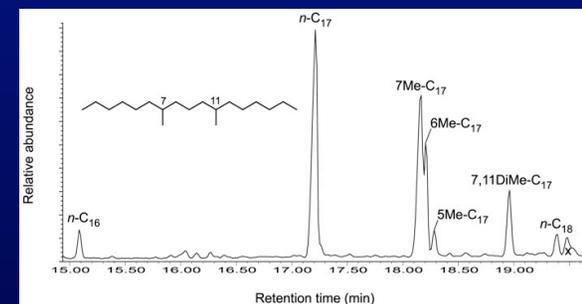
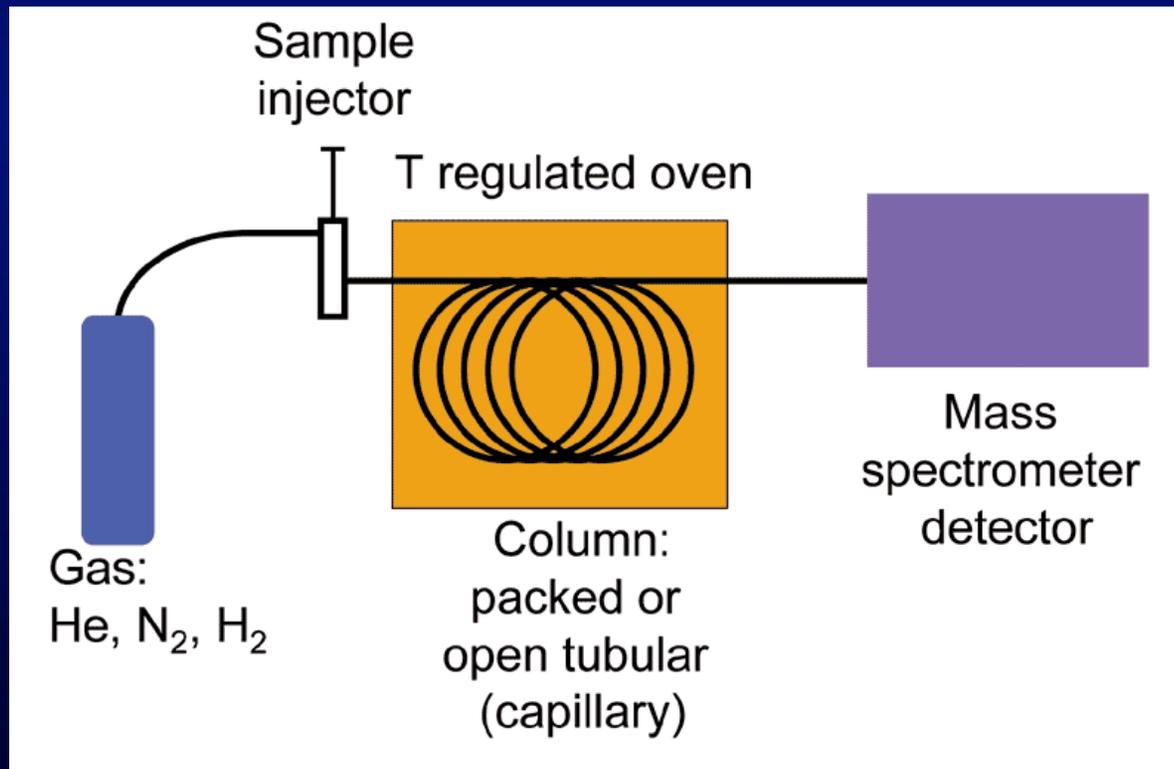
Gas chromatography-
mass spectroscopy

Hydrocarbons: mono-
and dimethylalkanes

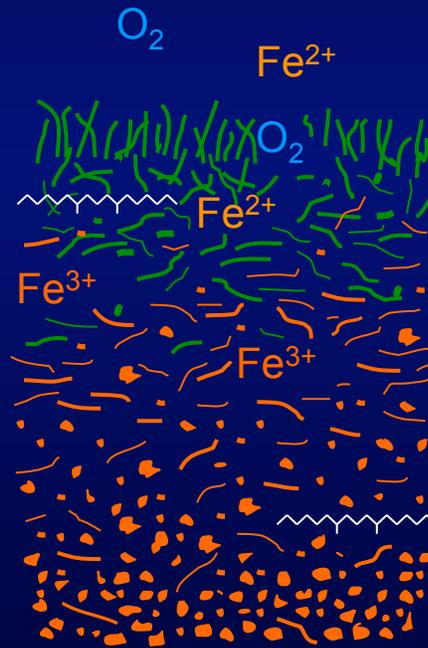
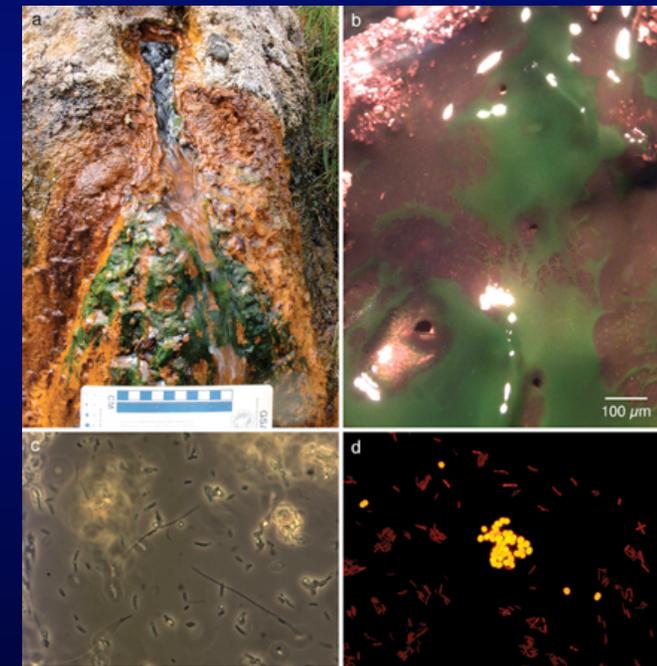
LIPIDS IN MICROBES



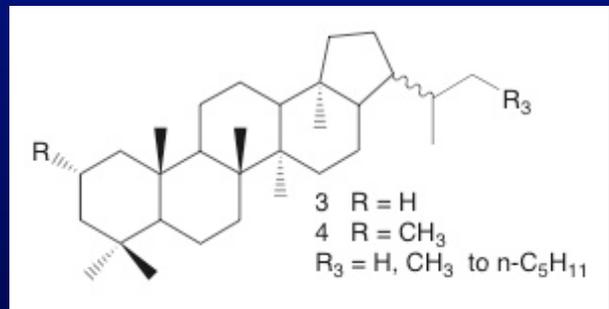
Gas chromatography-mass spectroscopy



LIPIDS IN OLD ROCKS



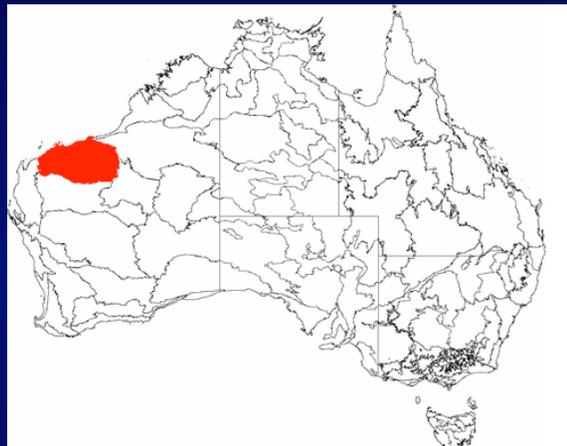
Cyanobacteria



2 α -methylhopane

Brocks et al., 1999

LIPIDS IN OLD ROCKS

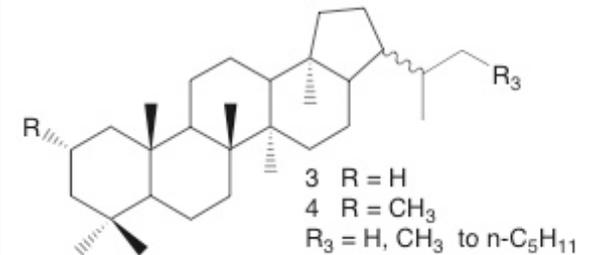


2.7 Billion years old!

Pilbara Craton, Australia



Cyanobacteria



2 α -methylhopane

ASTROBIOLOGY
LIFE IN THE UNIVERSE

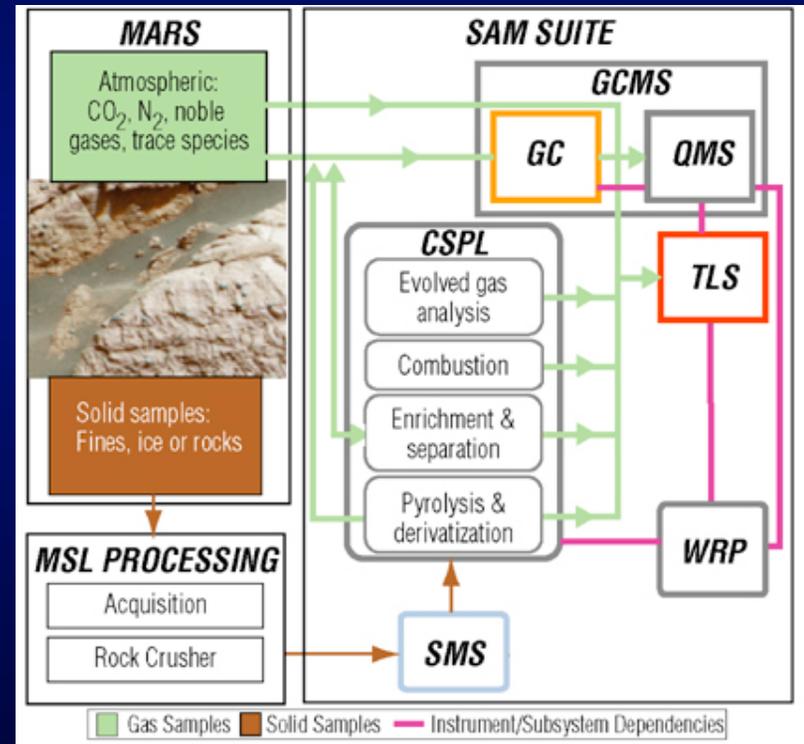
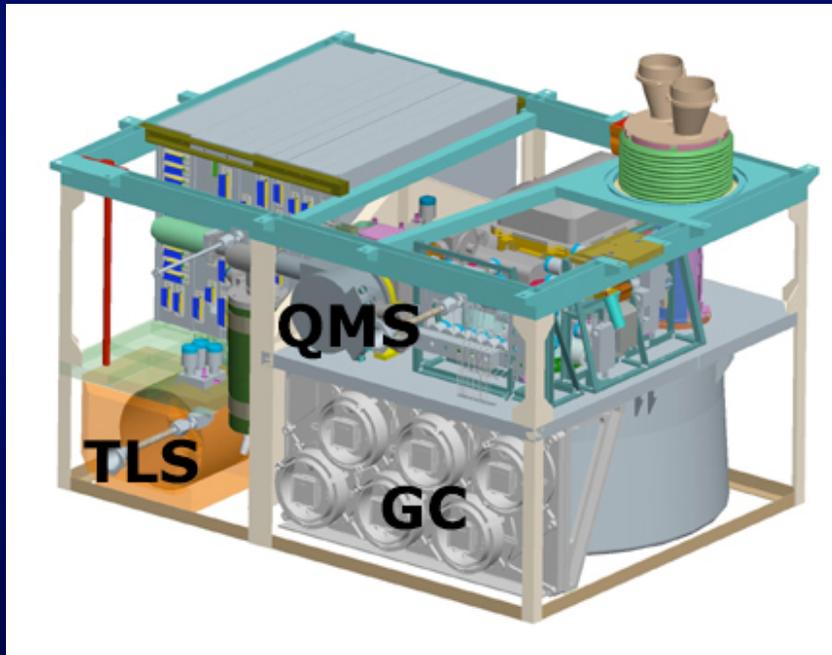
SEARCHING FOR LIPIDS ON MARS

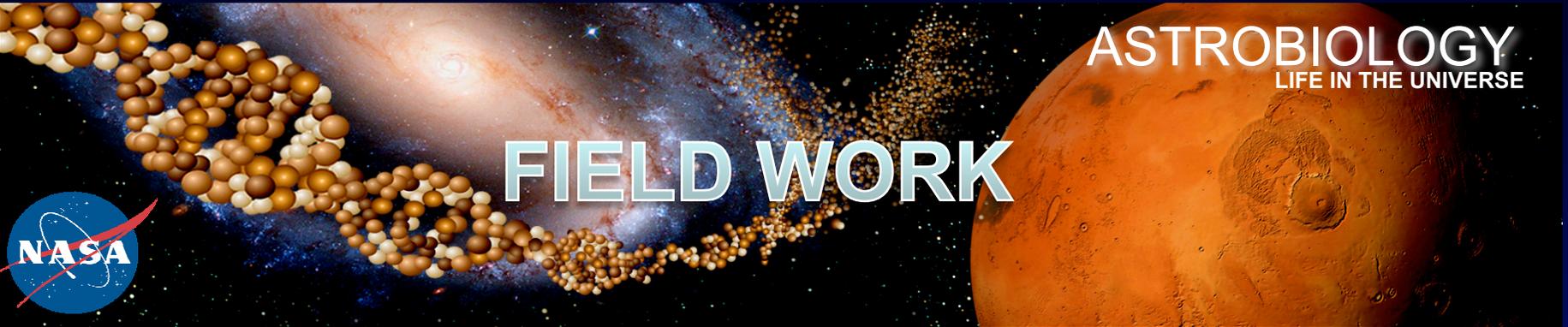


Mars Science Laboratory mission launching 2011



SEARCHING FOR LIPIDS ON MARS





Yellowstone National Park



ASTROBIOLOGY
LIFE IN THE UNIVERSE

FIELD WORK



Lassen Volcanic National Park
Astrobiology Student Interns - Red Bluff High School



Cyanidia



SUMMARY



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